Tennessee Science Curriculum Framework

Physics

Course Description

Physics is a laboratory science course that examines the relationship between matter and energy and how they interact. This course will have a strong emphasis in the mathematics of physics. Students explore physics concepts through an inquiry approach.

Physics students will study:

- Inquiry
- Mathematics of Physics
- Technology and Engineering
- Mechanics
- Thermodynamics
- Waves and Sound
- Light and Optics
- Electricity and Magnetism
- Atomic and Nuclear Physics

Embedded Inquiry

Conceptual Strand

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question

What tools, skills, and knowledge are needed to conduct scientific inquiry?

Course Level Expectations

CLE 3231.Inq.1 Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.

CLE 3231.Inq.2 Design and conduct scientific investigations to explore new phenomena, verify previous results, test how well a theory predicts, and compare opposing theories.

CLE 3231.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3231.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3231.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3231.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3231.Inq.1** Trace the historical development of a scientific principle or theory.
- ✓**3231.Inq.2** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3231.Inq.3** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3231.Inq.4** Analyze the components of a properly designed scientific investigation.
- ✓**3231.Inq.5** Perform an experiment to test a prediction.
- ✓**3231.Inq.6** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3231.Inq.7** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3231.Inq.8** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3231.Inq.9** Evaluate the accuracy and precision of data.
- ✓**3231.Inq.10** State a conclusion in terms of the relationship between two or more variables.
- ✓**3231.Inq.11** Defend a conclusion based on scientific evidence.
- ✓**3231.Inq.12** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3231.Inq.13** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3231.Inq.14** Suggest alternative explanations for the same set of observations.
- ✓**3231.Inq.15** Formulate and revise scientific explanations and models using logic and evidence.
- ✓**3231.Inq.16** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Technology and Engineering

Conceptual Strand

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question

How do science concepts, engineering skills, and applications of technology improve the quality of life?

Course Level Expectations

CLE 3231.T/E.1 Explore the impact of technology on social, political, and economic systems.

CLE 3231.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.

CLE 3231.T/E.3 Explain the relationship between the properties of a material and the use of the material in the application of a technology.

CLE 3231.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.T/E.1** Select appropriate tools and procedures best suited to conduct a specified scientific inquiry.

✓**3231.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

✓**3231.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.

✓**3231.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.

✓**3231.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.

✓**3231.T/E.6** Present research on current engineering technologies that contribute to improvements in our daily lives.

✓**3231.T/E.7** Design a series of multi-view drawings that can be used by others to construct an adaptive design and test its effectiveness.

Embedded Mathematics

Conceptual Strand

Physics applies mathematics to investigate questions, solve problems, and communicate findings.

Guiding Question

What mathematical skills and understandings are needed to successfully investigate physics?

Course Level Expectations

CLE.3231.Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.

CLE.3231.Math.2 Solve for variables in an algebraic formula.

CLE.3231.Math.3 Apply statistical techniques to manipulate data.

CLE.3231.Math.4 Investigate trigonometric connections to physics.

CLE.3231.Math.5 Utilize calculus to understand physics principles.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.Math.1** Plot points on the Cartesian coordinate graphing system.

✓**3231.Math.2** Graph basic relations and functions.
✓**3231.Math.3** Determine the slope of a linear function.
✓**3231.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
✓**3231.Math.5** Utilize a graphing calculator to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
✓**3231.Math.6** Solve for all variables based on a formula.
✓**3231.Math.7** Solve for the *t* – value, *p* (probability), and % of confidence between two lists of data (manipulated variables and responding variables).
✓**3231.Math.8** Reject or accept a null hypothesis based on statistical analysis.
✓**3231.Math.9** Find the regression line (equation) between data for manipulated and responding variables.
✓**3231.Math.10** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
✓**3231.Math.11** Apply the laws of sine and cosine to solve vector problems.
✓**3231.Math.12** Solve mechanics problems using the quadratic formula.
✓**3231.Math.13** Find the derivative (velocity function) of a distance (displacement) function.
✓**3231.Math.14** Find the derivative (acceleration function) of a velocity function.
✓**3231.Math.15** Link various calculus procedures to solve physics problems.

Standard 1 – Mechanics

Conceptual Strand 1

Laws and properties of mechanics are the foundations of physics.

Guiding Question 1

How do the laws and properties of mechanics govern the basic understanding of physics.

Course Level Expectations

CLE 3231.1.1 Investigate fundamental physical quantities of mass and time.
CLE 3231.1.2 Analyze and apply Newton's three laws of motion.
CLE 3231.1.3 Understand work, energy, and power.
CLE 3231.1.4 Investigate kinematics and dynamics.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.1.1** Explore displacement, velocity, and acceleration [Average Velocity: $v_{av} = (d_f-d_i)/(t_f-t_i)$; Final Velocity: $v_f = v_i+a\Delta t$; Final Velocity of Falling: $v_f = v_i+g\Delta t$; Average Acceleration: $a_{av} = (v_f-v_i)/(t_f-t_i)$; Displacement: $d = v_i \Delta t+(1/2)\, a\Delta t^2$; Displacement of Falling: $\Delta d = v_i \Delta t +(1/2)g\, \Delta t^2$].
✓**3231.1.2** Analyze vector diagrams and solve composition and resolution problems for force and momentum.
✓**3231.1.3** Explore characteristics of rectilinear motion and create distance-time graphs (velocity), velocity-time graphs (acceleration and distance).

✓**3231.1.4** Investigate the characteristics of centripetal motion and centripetal acceleration [Centripetal Force: $F_c = (mv^2)/r$; Angular Velocity: $\omega=\Delta\theta/\Delta t$; Angular Acceleration: $\alpha = \Delta\omega/\Delta t$].

✓**3231.1.5** Evaluate the dynamics of systems in motion including friction, gravity, impulse and momentum, change in momentum, and conservation of momentum. [Coefficient of Friction: $\mu = F_f/F_N$; Law of Universal Gravitation: $F_G = (G\, m_1 m_2)/d^2$; Impulse and Change of Momentum: $F\,\Delta t = m\Delta t$].

✓**3231.1.6** Investigate projectile motion. [Parabolic Equations with Quadratic Formula:

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

].

✓**3231.1.7** Apply mathematics to solve motion problems.

✓**3231.1.8** Experiment with elastic and inelastic collisions.

✓**3231.1.9** Experiment with pendulums [Pendulum period: $T = 2\pi\sqrt{l/g}$]

✓**3231.1.10** Utilize trigonometry and vector analysis to solve force and momentum problems [Sine, Cosine, Tangent Functions, Law of Sine, and Law of Cosine].

✓**3231.1.11** Apply elementary calculus to solve motion problems [Velocity = derivative of and acceleration = derivative of velocity].

✓**3231.1.12** Experiment with elastic and inelastic collisions [Elastic Collisions in One Dimension: $m_1v_1 + m_2v_2 = m_1v_3+m_2v_4$; Inelastic Collision in One Dimension: $m_1v_1+m_2v_2 = (m_1+m_2)v_3$

✓**3231.1.13** Distinguish between mass and weight using base units in the SI system.

✓**3231.1.14** Associate time with the independent variable in most experiments.

✓**3231.1.15** Relate inertia, force or action-reaction forces to Newton's three laws of motion.

✓**3231.1.16** Compare, contrast, and apply characteristic properties of scalar and vector quantities.

✓**3231.1.17** Investigate the definitions of force, work, power, kinetic energy, and potential energy. [Force: $F = ma$; Work: $W = Fd$; Power: $P = (F\Delta d)/\Delta t$; Kinetic Energy: $E_K = 0.5mv^2$; Potential Energy: $E_P = mg\Delta h$].

✓**3231.1.18** Analyze the characteristics of energy, conservation of energy including friction, and gravitational potential energy [Gravitational Potential Energy: $E_p=mg\Delta h$].

✓**3231.1.19** Relate work and power to various simple machines, mechanical advantage of different machines, and recognize simple machines that are combined to form compound machines [Work: $W= F\Delta d$; Power: $p = (F\Delta d)/\Delta t$; Efficiency, Efficiency = $(W_{OUT}/W_{IN})x100\%$].

✓**3231.1.20** Describe rotational equilibrium and relate this factor to torque [Rotational Inertia: $T = I\alpha$; Torque: $T = Fr$].

Standard 2 – Thermodynamics

Conceptual Strand 2

The principles and laws of thermodynamics are essential for understanding the concept of energy.

Guiding Question 2

How do the laws of thermodynamics relate to understanding the conservation of energy?

Course Level Expectations

CLE 3231.2.1 Develop an understanding of heat and internal energy.
CLE 3231.2.2 Compare Celsius, Kelvin and the Absolute temperature scales.
CLE 3231.2.3 Investigate exchanges in internal energy.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3231.2.1** Investigate temperature in relationship to kinetic energy.
- ✓**3231.2.2** Identify the characteristics of internal energy and temperature/heat (joules/calories).
- ✓**3231.2.3** Experiment with change in heat content (quantity of thermal energy) and relate to kinetic energy and specific heat.
- ✓**3231.2.4** Investigate potential energy changes (phase changes) of heat of fusion, heat of vaporization, and heat of sublimation [Change in Heat: $\Delta Q= mH_v$ and $\Delta Q= mH_v$].
- ✓**3231.2.5** Explore thermal expansion and contraction [Linear Expansion: $\Delta l = l_i \alpha \Delta T$; Volumetric Expansion: $\Delta V= V_i \beta \Delta T$].
- ✓**3231.2.6** Apply the second law of thermodynamics to the Carnot engine.
- ✓**3231.2.7** Apply the Laws of Thermodynamics to the atmospheric levels of the earth (i.e., greenhouse effect and global warming)
- ✓**3231.2.8** Recognize that absolute zero is the absence of molecular kinetic energy.
- ✓**3231.2.9** Relate the First Law of Thermodynamics as an application of the Law of Conservation of Energy and heat transfer through conduction, convection, and radiation. [Heat Lost = Heat Gained, $Q_L= Q_G$].
- ✓**3231.2.10** Relate change in heat content (quantity of thermal energy) to kinetic energy and specific heat [Change in Heat: $\Delta Q=mC\Delta T$]

Standard 3 – Waves

Conceptual Strand 3

Understanding sound and light is accomplished by investigating wave behavior.

Guiding Question 3

How do the properties of mechanical waves, sound, and light explain the behavior of waves?

Course Level Expectations

CLE 3231.3.1 Explore conditions associated with simple harmonic motion.
CLE 3231.3.2 Investigate Hooke's law.
CLE 3231.3.3 Understand wave mechanics.
CLE 3231.3.4 Examine the Doppler Effect.
CLE 3231.3.5 Explore the characteristics and properties of sound.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.3.1** Investigate simple harmonic motion.
✓**3231.3.2** Investigate and analyze wavelength, frequency, and amplitude of longitudinal and transverse waves.
✓**3231.3.3** Describe a wave interaction as reflection, refraction, diffraction, or interference.
✓**3231.3.4** Explore Hooke's Law.
✓**3231.3.5** Investigate reflection, refraction, diffraction, and interference of sound waves.
✓**3231.3.6** Compare mechanical and electromagnetic waves.
✓**3231.3.7** Explain the Doppler Effect

Source moving toward stationary listener:

$$f_{LF} = f_s \frac{v}{v - v_s}$$

Source moving away from stationary listener:

$$f_{LB} = f_s \frac{v}{v + v_s}$$

Listener moving toward stationary source:

$$f_{LC} = f_s \frac{v + v_{LC}}{v}$$

Listener moving away from stationary source:

$$f_{LO} = f_s \frac{v - v_{LO}}{v}$$

✓**3231.3.8** Determine the speed of sound experimentally and describe the effects various materials and temperatures on sound transmission.
✓**3231.3.9** Measure spring constants.
✓**3231.3.10** Solve problems related to wave length, frequency and speed [Wave velocity: $v = f\lambda$].
✓**3231.3.11** Determine the speed of sound experimentally using various materials and temperatures [Sound velocity: $v_s = f\lambda$; Sound velocity (using air temperature): $v_s = 331.5\text{m/s} + (0.56\ \text{m/s}\ ^{o}\text{C})\ (T)$].
✓**3231.3.12** Describe simple harmonic motion.
✓**3231.3.13** Compare the wave characteristics of natural auditory phenomena.

Standard 4 – Optics

Conceptual Strand 4

Understanding optics is accomplished by investigating the behavior and laws of light.

Guiding Question 4

How do the properties and behavior of light relate to the basic principles of optics?

Course Level Expectations

CLE 3231.4.1 Describe the characteristics of the electromagnetic spectrum.
CLE 3231.4.2 Investigate the interaction of light waves.
CLE 3231.4.3 Explore the optics of lenses.
CLE 3231.4.4 Analyze the optics of mirrors.
CLE 3231.4.5 Investigate the phenomenon of color.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.4.1** Explore properties of electromagnetic radiation.
✓**3231.4.2** Examine properties of light waves.
✓**3231.4.3** Investigate the polarization of light.
✓**3231.4.4** Investigate the optical properties of plane and curved mirrors [Focal length:$1/f = 1/d_o + 1/d_i$; Images in mirrors and lens, $h_i/h_o = d_i/d_o$]
✓**3231.4.5** Investigate the optical properties of plane and curved mirrors.
✓**3231.4.6** Solve problems related to Snell's law [Index of refraction: $n = (\sin \theta_r / \sin \theta_i)$; Snell's law: $n_i \sin \theta_i = n_r \sin \theta_r$].
✓**3231.4.7** Explore the formation of color (both additive and subtractive properties) [Additive Color Theory: W= B+G+R: Y= G+R: =B+G: M = R+B; Subtractive Color Theory: B=W–Y: C= W–R: M=W–G].
✓**3231.4.8** Draw, explain, and solve problems for the optics of mirrors and lenses.
✓**3231.4.9** Investigate optical phenomena (i.e., mirage, optical illusions, and dichromatic lens effect).
✓**3231.4.10** Differentiate among transmission, reflection, refraction, diffraction, and interference of light waves.

Standard 5 – Electricity and Magnetism

Conceptual Strand 5

Understanding electricity and magnetism is explained by the physics of electrons and magnets.

Guiding Question 5

How do the properties of electricity and magnetism relate to the physics of electrons and magnets?

Course Level Expectations

CLE 3231.5.1 Examine the properties of electric forces, electric charges, and electric fields.

CLE 3231.5.2 Explore the flow of charge and electric currents.

CLE 3231.5.3 Investigate Ohm's law.

CLE 3231.5.4 Compare and contrast series and parallel circuits.

CLE 3231.5.5 Analyze schematic diagrams.

CLE 3231.5.6 Understand magnetic poles, magnetic fields, and investigate electromagnetic induction.

Checks for Understanding (Formative/Summative Assessment)

✓**3231.5.1** Create a simple electromagnet. .

✓**3231.5.2** Draw an electric field, given a scenario of charged particles.

✓**3231.5.3** Solve problems of resistance using Ohm's law [E = IR (or V=IR)].

✓**3231.5.4** Draw and explain series and parallel circuits.

✓**3231.5.5** Solve problems related to voltage, amperage, and resistance [Voltage, V = IR; Series circuit formulas, $R_T = R_1+R_2+\ldots$, $I_T = I_1 = I_2 = \ldots$, $V_T = V_1+ V_2+\ldots$; Parallel circuit formulas, $1/R_T = 1/R_1+1/R_2+ \ldots$, $I_T = I_1+I_2+ \ldots$, $V_T = V_1=V_2 = \ldots$].

✓**3231.5.6** Build series and parallel circuits to demonstrate how they function.

✓**3231.5.7** Demonstrate a generated current by electromagnetic induction.

✓**3231.5.8** Design a lab to demonstrate the flow of charged particles and an electric current.

✓**3231.5.9** Analyze a given group of charges for repulsion and attraction.

✓**3231.5.10** Distinguish between charged particles related to repulsion and attraction.

✓**3231.5.11** Describe the electric field that fills the space around a charged particle or group of charges [Coulomb's law of electrostatics, $F= k (Q_1Q_2)/d^2$].

✓**3231.5.12** Identify components of series and parallel circuits and solve problems related to voltage, amperage, and resistance.

✓**3231.5.13** Describe how current is generated by electromagnetic induction.

Standard 6 – Nuclear Physics

Conceptual Strand 6

A deep understanding of particle physics is accomplished by investigating the properties of nuclear physics.

Guiding Question 6

How is the investigation of the properties of nuclear physics related to understanding nuclear particles?

Course Level Expectations

CLE 3231.6.1 Investigate the properties and structure of the atom.

CLE 3231.6.2 Compare and contrast the Bohr model and the quantum model of the atom.
CLE 3231.6.3 Explore the dynamics of the nucleus: radioactivity, nuclear decay, radiocarbon/uranium dating and half-life.
CLE 3231.6.4 Compare and contrast nuclear fission and nuclear fusion.
CLE 3231.6.5 Investigate the quantum theory.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3231.6.1** Write and balance equations for the three forms of radioactive decay.
- ✓**3231.6.2** Solve half-life problems [Decay constant: $k=0.693/T_{(1/2)}$; Nuclear decay: $A_f=A_oe^{kt}$].
- ✓**3231.6.3** Explain dating methods using carbon-14 or uranium.
- ✓**3231.6.4** Investigate the concept of half-life.
- ✓**3231.6.5** Explain how particles behave like waves.
- ✓**3231.6.6** Distinguish between coherent and incoherent light.
- ✓**3231.6.7** Recognize how the quantum theory explains the photoelectric effect.
- ✓**3231.6.8** Investigate the history and current events associated with nuclear and radioactive science.
- ✓**3231.6.9** Identify the parts of an atom.
- ✓**3231.6.10** Describe the properties and location of subatomic particles.
- ✓**3231.6.11** Describe three forms of radioactivity.
- ✓**3231.6.12** Distinguish between nuclear fission and nuclear fusion.
- ✓**3231.6.13** Distinguish between the Bohr model and the quantum model of an atom.
- ✓**3231.6.14** Explain the changes in atomic number or mass number for each form of radioactivity.
- ✓**3231.6.15** Discuss transmutation and transuranium.
- ✓**3231.6.16** Explain how particles behave like waves.
- ✓**3231.6.17** Describe how a laser is produced.
- ✓**3231.6.18** Recognize how the quantum theory explains the photoelectric effect.